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Learner-Centered Use of Student Response Systems Improves Performance in Large Class Environments

Samuel B. Pond, III[1]
North Carolina State University, Raleigh, NC 27695-7650

Abstract

At the college level, students often participate in introductory courses with large class enrollments that tend to produce many challenges to effective teaching and learning. Many teachers are concerned that this class environment fails to accommodate higher-level thinking and learning. I offer a brief rationale for why a student-response system (a computer-assisted polling tool), when well incorporated into lectures, can effectively address the basis of some of these concerns and should improve teaching and learning. An empirical assessment reveals that when used to engage students in lecture, this technology can help many of them achieve higher test scores.

Keywords: Student response systems, clickers, technology, participation, engagement.

Students who are just entering into the university often take their introductory courses in large lecture halls. Not only are these students receiving their first exposure to novel topics, but they also are usually getting their first experience with large classroom dynamics that present special challenges to both teachers and students. Some educators have made a very good case that large classrooms break many tenets of effective teaching and learning (Herreid, 2006; Trees & Jackson, 2007). Entire books are devoted to addressing the unique challenges of this learning environment (e.g., McKeachie, Chism, Menges, Svinicki, & Weinstein, 1994; Stanley & Porter, 2002). Perhaps the greatest challenge mentioned is the lack of immediate personal communication between students and teacher about what is and is not being learned (Nagle, 2002).

Roschelle, Penuel, and Abrahamson (2004) observed that effective learning occurs in classroom environments that are learner-, knowledge-, assessment-, and community-centered. Obviously, teachers need to produce lectures that are informative; that is, are knowledge-centered. Beyond this, however, teachers need to create a learner-centered environment where their teaching methods encourage students to think actively during lectures and to engage with material they are hearing. It is also important that training be assessment-centered so that it effectively positions students to learn more by giving them immediate feedback about their understanding of the lecture material. Finally, acknowledging that learning is a social event, Roschelle and colleagues emphasized how important it is for a teacher to create a sense of community in the classroom by pointing out in

[1] Corresponding author's email: sbpond@ncsu.edu

word and practice that students are sharing a common purpose, which is to learn the material at hand. Generally, the large classroom setting has excelled in the realm of being knowledge-centered, but it has suffered in quality with respect to being learner-centered, assessment-centered, and community-centered especially when compared to smaller classes. I contend that the appropriate use of a student-response system can help ameliorate this situation.

Students who are actively engaged in the learning process learn more than do students not so engaged (Benjamin, 1991; Langer, 2000; Stanley & Porter, 2002; Yoder & Hochevar, 2005). They engage in learning when they personally identify with the material taught, when they see that the material is relevant, or when they see that the topic is important to other students around them. Students are more likely to care about learning when they receive evidence that the teacher cares about what they are learning, and teachers are more effective when they obtain feedback about their teaching (Teven & McCroskey, 1997). In other words, teachers in large classroom settings need feedback, too. They need to know if their students are "with them" in the lesson or if the material needs to be presented again in a different way.

Indeed, the large classroom setting is a difficult place to ask and answer questions, and for effective learning to take place questions and answers need to be generated (Sorcinelli, 2002). Often, however, the few students who are bold enough to ask questions in this setting are not representative of the rest of the class (Graham, Tripp, Seawright, & Joeckel, 2007; Herreid, 2006). The most vocal students under these conditions, for example, sometimes ask strange or personal questions that are difficult to answer effectively and sensitively in a large classroom setting. Acoustic restraints and other interpersonal factors associated with the large class can prevent one from probing and clarifying with flexibility what the student is asking.

Consequently, because students ask questions in a large classroom setting that teachers cannot always field well, there may develop an implicit understanding between the teacher and student to forego these exchanges. Furthermore, answering questions in this setting can be counterproductive to student learning because the flow of a lecture is upset and the teacher cannot take into consideration the various needs and perspectives of a large and diverse audience efficiently or adequately.

Although not a panacea to all the barriers inherent to the large classroom environment, when properly introduced and used, student response systems can help teachers overcome many of these sorts of challenges (Bruff, 2009; Graham et al., 2007; Herreid, 2006; Trees & Jackson, 2007). Although there are various student response systems commercially available, they all contain three basic components: (1) hand-held transmitters (hereinafter referred to as "clickers") used by students to answer questions posed to them, (2) a receiver that is connected to a teacher's computer to register clicker signals, and (3) software installed on the teacher's computer that is dedicated to processing and graphically presenting students' responses to questions. When an instructor presents a multiple-choice item to the class on a PowerPoint slide during a lecture, students are immediately able to register their answers using their clickers, and the instructor can provide immedi-

ate visual feedback to the whole class. By asking various types of questions, teachers can use this technology effectively to tap into the diversity of a large classroom to create teaching points and illustrate real world issues to which the whole class can become attuned (Beekes, 2006; Bruff, 2009; Ferguson, 1992; Graham et al., 2007).

To date, a number of researchers have evaluated clicker technology to varying extents and purposes and have found it to be quite promising (Stowell & Nelson, 2007). Cleary (2008) has reported on the advantages of using clickers for gathering research data. Others, including Morling, McAuliffe, Cohen, and DiLorenzo (2008) have reported instructional gains when using clickers to administer in-class quizzes. Researchers have examined student attitudes toward clickers and the context within which clickers work best (Herreid, 2006; Trees & Jackson, 2007). The current study adds to this growing literature by investigating the relationship between clicker use and student test performance by analyzing the detailed information collected on each student with clicker software. I specifically address the question of whether clicker activities help to create a class environment that contributes to student test performance. Using the terminology of Roschelle et al. (2004), my particular interest is in accessing a learner-centered application of clicker technology.

Method

Participants

One hundred and seventy-one students enrolled in an introductory psychology course taught in a large R-1, land-grant University located in the Southeastern United States provided data for the primary analyses of this study. Students participating in the study had the following demographic characteristics: 58% male, 42% female; 81% Caucasian, 7% African-American, 3% Hispanic, 4% Asian, 4% other, and 1% not specified. Student participants ranged in age from 17 to 31 years, with a median age of 19. The majority of the students (58%) were first-year undergraduates as might be expected in an introductory level psychology course. The remainder of the participants consisted of 23% sophomores, 9% juniors, 5% seniors, and 5% undergraduate special students (i.e., students not enrolled in a degree program in the university).

Procedure

Research shows that the way teachers incorporate a student response system into their instruction and grading procedures likely influences the impact that it will have on students' general acceptance of the system and its effects on learning (Bruff, 2009; Trees & Jackson, 2007). At the beginning of the semester, students read on the course syllabus and heard from the instructor during an introductory lecture that he would be using the response system mainly to encourage them to actively participate and interact with the lecture material. Students also heard that using their clickers would earn them a small amount of participation credit. As much as possible, the lectures included clicker activity in a way that might promote a sense of competence and self-determination in a student (Graham et al., 2007; Ryan & Deci, 2000).

Throughout the semester, students responded to various kinds of clicker items presented to them via PowerPoint presentations. Since clicker activity emphasized "learner-centered" more than an "assessment-centered" application of the clicker technology, students received fractions of a point each day for simply responding to items. In other words, the instructor used the clicker questions to encourage students to actively attend to and respond to lecture information. The students knew that the clickers were not going to be used for administering quizzes or for just taking attendance; a practice that would be primarily in line with assessment-centered application of clicker technology.

To engage students during lectures, the instructor posed various kinds of questions. Some of the items to which students responded simply requested opinions and personal information (e.g., "Do you know someone with Alzheimer's disease;" "Are you right or left-handed"). Other items assessed students' knowledge of facts (e.g., "The retina consists of rods and ___"). These items referred to material already covered in class to review or check student learning. To stimulate critical thinking and to extend the application of previously covered information, however, students sometimes to responded to factual items *before* hearing about the information in lecture. Finally, lectures included other items to facilitate in-class demonstrations. For example, the instructor converted demonstrations that formerly required students in the class to respond by raising their hands to ones that students could respond to by "clicking." Thus, instead of "look around the room" approximations that may be difficult to make in large auditorium settings, students quickly received accurate visual displays of response distributions on a PowerPoint slide. These visual displays literally and symbolically incorporated the students' involvement in the lecture presentation. Students received a clear indication that others in class were thinking and answering as a community of learners. Although the instructor presented a variety of items to students during lecture, he did not try to vary this systematically.

The instructor did not radically change the content of his lectures when using the student response system and was able to cover the same amount of material as in previous semesters. The main impact on the lecture was the addition of the clicker items to the PowerPoint presentations. Although there are many student response systems available, the instructor used TurningPoint 2008 developed by Turning Technologies, LLC (see Graham et al., 2007, for an excellent description of this system).

Students were not required to have clickers, but in fact, all but five students purchased them. It is likely that the availability of participation credit encouraged them to purchase the clickers, even though the instructor made it clear to students that points not obtained by participation could otherwise be acquired by answering bonus point questions on tests. Students indicated on a course and instructor evaluation survey conducted at midterm that they were generally positive about using clickers: specifically, about 70% of the students strongly agreed that the "clicker was a valuable aid to learning."

Measures

Clicker Activity. I used the software accompanying the student response system to record clicker activity on a daily basis for each student. The software creates a text file that contains accounts of how many times each of the students used his or her clicker. In addition, for items that had clear correct and incorrect answers, the software also tracked the percentage of clicker items that each student answered correctly. Daily files were merged to produce one large dataset to assess how students used their clickers over the semester. From this dataset, I derived two indices of clicker activity: 1) *clicker use* was a measure of the total number of times a student used his or her clicker during the semester, and 2) *clicker performance* was a measure of the average percentage of correct/incorrect items that students answered correctly per day over the semester.

Test Performance. I measured test performance by summing the points scored by students on three multiple-choice format tests administered at equal intervals across the last three quarters of the semester. Each student's first quarter test score served as a control variable in the data analyses described later. It is important to note that the tests did not include clicker items used in the lectures, although these tests certainly assessed the information contained in these items. Consequently, any relationship that might exist between test performance and clicker performance would not be the result of these two measures containing common items.

Class Absence. A teaching assistant checked class attendance using a seating chart and recorded students as being "present" if a seat assigned to them was occupied. This measure also served as a control variable in a manner described more fully later.

Results

Descriptive statistics of and intercorrelations among variables are presented in Table 1. As would be expected, class absence had strong negative correlations with each of the clicker activity scores (clicker use, $r(171) = -.87$; clicker performance, $r(171) = -.82$) and was negatively correlated with test performance ($r(171) = -.44$). The two clicker activity scores were highly correlated ($r(171) = .93$). Those who used their clickers frequently also answered a larger percentage of performance items correctly on a daily basis. In addition, clicker performance was more highly correlated with test performance ($r(171) = .55$) than with clicker use ($r(171) = .42$) and the difference between these correlations was significant, $t(168) = 5.649$, $p < .001$.

Students used their clickers an average of 83.8 times over 35 class meetings during the semester. In addition, of those items that students could answer either correctly or incorrectly, they answered an average 39% of the items per day correctly. Clearly, students were answering these particular clicker questions incorrectly the majority of time. It is possible that lower performance on the "critical thinking" items, which I used to probe students' knowledge of subjects that I had not yet covered in lecture, partially accounts for the low percentage of items answered correctly.

Table 1. Intercorrelations between Clicker Activity Scales, Absence, and Test Scores

Variable	*M*	*SD*	1	2	3	4
1) Class Absences	7.70	7.80				
2) Score on Test 1	35.60	7.34	-.30			
3) Test Performance	117.25	16.47	-.44	.54		
4) Clicker Use	83.75	30.70	-.87	.30	.42	
5) Clicker Performance	39.17	17.11	-.82	.39	.55	.93

$N = 171$. All correlations are significant at $p < .01$ level (2-tailed).

Regression Analyses

A three-step hierarchical regression analysis assessed the impact of clicker activity on test performance. In the first step, test performance was regressed onto the score students achieved on Test 1 and the number of times they were absent from class. The score on the first test of the semester was included to control for the effect of individual differences in student test-taking ability and for differences in general background knowledge of psychology among students. The total number of classes missed was included in the regression equation to control for the effect that simply being (or not being) in the class had on test performance. Controlling for the number of classes missed was particularly important to do given the amount of shared variance between absence and the two clicker activity variables. In steps 2 and 3 of the regression analysis, clicker performance and clicker use, respectively, were entered into the regression equation to predict test performance.

Table 2 shows that a considerable amount of test performance variance was accounted for with all of the predictors in the equation, $R^2 = .472$, $F(4, 166) = 37.05$, $p < .001$; Test 1 scores and class absences accounted for the bulk of this variance ($R^2 = .381$). Nevertheless, clicker performance predicted a small but statistically significant additional amount of test performance variance above the control variables, $\Delta R^2 = .047$, $F(1, 167) = 13.62$, $p < .001$. Then, in step 3, clicker use also predicted a small but statistically significant additional amount of test performance above that accounted for by clicker performance, $\Delta R^2 = .044$, $F(1, 166) = 13.94$, $p < .001$. The standardized regression coefficients associated with Test 1 (.34), clicker performance (.87) and clicker use (-.69) were significant ($p < .001$). The coefficient associated with clicker performance indicated that a high level of clicking correctly (i.e., answering correct/incorrect clicker items correctly) was associated with higher test performance. Interestingly, the negative coefficient associated with clicker use (i.e., simply answering or not answering with a clicker after controlling for clicker performance) indicated that simply clicking a lot was associated with lower test performance. Although each clicker activity variable predicts a uniquely significant and meaningful amount of test performance variance (both positive and negative) in the expected directions, researchers should interpret the regression coefficients associated with these two highly correlated variables cautiously (Cohen & Cohen, 2003; Johnson, 2000).

Table 2. Summary of Hierarchical Regression Analyses for Clicker Activity Predicting Test Performance after Controlling for Score on Test 1 and Class Absences (N = 171)

Step and Independent Variables	*B*	*SE B*	β	Total R^2	ΔR^2
Step 1					
Score on Test 1	1.008	.143	.449**		
Class Absences	-.655	.134	-.310**		
				.381**	
Step 2					
Score on Test 1	.862	.143	.384**		
Class Absences	-.006	.218	-.003		
Clicker Performance	.382	.103	.396**		
				.427**	.047**
Step 3					
Score on Test 1	.764	.140	.341**		
Class Absences	-.481	.246	-.228		
Clicker Performance	.382	.103	.873**		
Clicker Use	-.371	.099	-.691**		
				.472**	.044**

**$p < .001$.

To get a better idea of how using clickers influenced test scores, I compared the test performance of students who used clickers to the test performance of students in two previous semesters who had not used clickers. Other than class standing, no demographic data (i.e., race, age, and sex) were available for the comparison classes. The classes are slightly different with respect to class standing. In one of the semesters (Class 2) 93% of the students were either freshmen or sophomores in comparison to 83% and 85% of the students in Class 1 and the class using clickers, respectively. Because in previous semesters I administered four 55-item tests instead of four 53-item tests, I adjusted test score values so that they would be comparable across all semesters. I simply adjusted the current semester scores by multiplying the percentage correct by 220. For example, a total score of 190 would be adjusted to 197.12 (= .896 X 220). It is important to note that despite the fact that the number of items on tests differed across the semesters, analyses of performance data indicate that the tests were essentially parallel in content. Prior to classifying students in the current semester into low and high clicker use groups, an ANOVA showed that there were no significant differences in total test scores across the three semesters, $F(2, 528) = .047$, *ns*.

I then tested for differences in means across four groups of students: current semester, high clicker activity; current semester, low clicker activity; previous semester class 1, no clickers ($n = 178$); and previous semester class 2, no clickers ($n = 182$). High and low

clicker activity during the current semester class was determined by taking a median split on clicker performance and clicker use, respectively. Mean clicker performance and clicker use for each group appear in Table 3.

Table 3. Test Score across Three Classes as a Function of Clicker Activity

	Test Scores *M* (*SD*)	*n*
Current Semester Class	163.60 (20.35)	171
Low Clicker Use	156.30 (21.16)	78
High Clicker Use	169.73 (17.53)	93
Low Clicker Performance	154.38 (20.07)	87
High Clicker Performance	173.15 (15.80)	84
Previous Semester Class 1	162.06 (20.58)	178
Previous Semester Class 2	161.45 (23.17)	182

Because clicker usage was so highly correlated with class attendance, I conducted an ANCOVA to control for class attendance when testing for differences between means.

The results of this analysis appear in Table 4. Although the high clicker use group had the highest test performance and the low clicker use group had the lowest test performance, there were no significant mean differences in test scores when high and low clicker use groups were compared to the mean test scores obtained in other semesters, $F(3, 525) = 1.44$, *ns*. Small but significant differences in mean test scores were found, however, when groups formed on the basis of clicker performance were compared, $F(3, 525) = 4.48$, $p < .01$, $h^2 = .03$. Bonferroni *t*-tests revealed that the test performance of the group that performed well on the clicker questions for which a correct or incorrect response could be assessed was significantly higher than the test performance of all the other groups. Likewise, the group formed by low clicker performance had significantly worse test performance than any of the other groups had. Figure 1 shows differences in means across groups.

Discussion

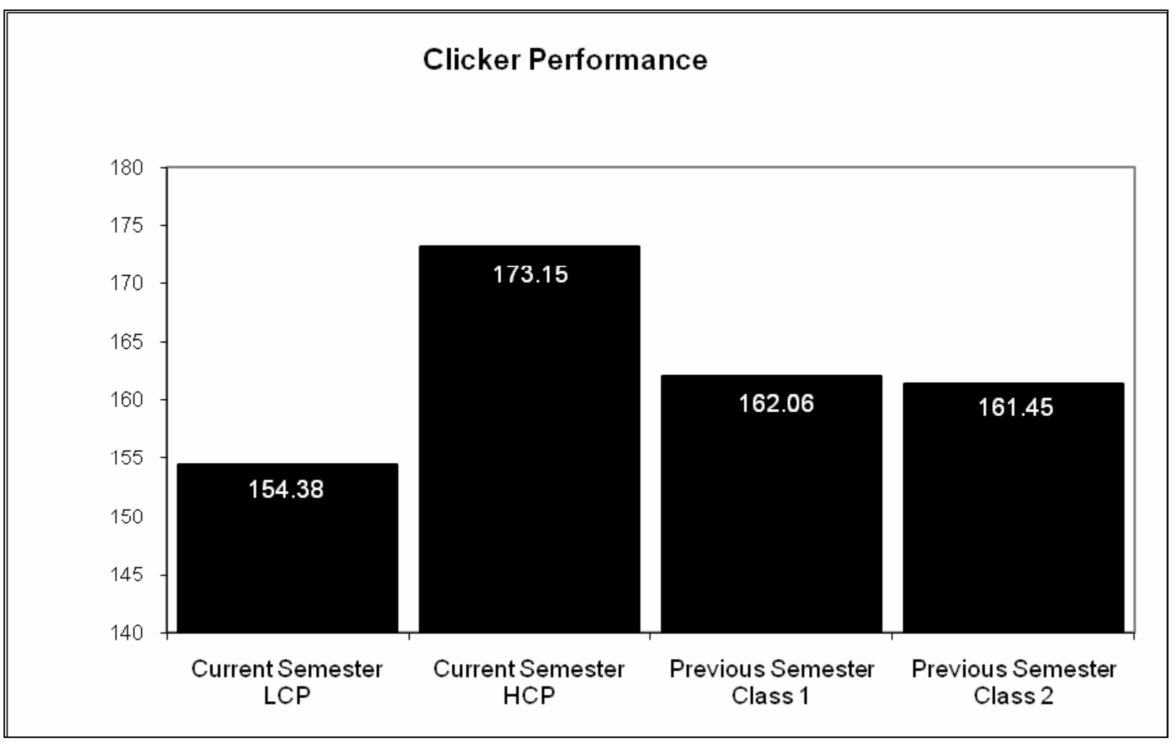
The premise of this study was that teachers could offset some of the barriers to training in a large classroom setting by using a student response system. Not surprisingly, class attendance alone significantly improves test performance, but the evidence presented here indicates that while effect sizes were not large, “active attendance,” as implied by higher clicker performance, contributes to test performance over and above mere class attendance. The results of this study indicate that test performance increases by a small but statistically significantly margin among students who used their clickers on a regular basis. Even after controlling for Test 1 scores (which functioned as a proxy for ability), answering clicker questions correctly during class predicted later test performance. This

Table 4. Analysis of Covariance of Test Scores across Different Semesters after Controlling for Absence from Class

Source	*SS*	*MS*	*df*	*F*
		Clicker Use[a]		
Class Absence	22470.51	22470.51	1	53.94***
Semester	1802.48	600.83	3	1.44
Error	218718.04	416.61	525	
		Clicker Performance[b]		
Class Absence	22470.51	22470.51	1	54.87***
Semester	5509.85	1836.62	3	4.48**
Error	215010.67	409.54	525	

[a]Number of times over the semester the clicker was used at least once during a class.
[b]Percentage of questions answered correctly each day averaged over the semester.
$N = 530$. *** $p < .0001$. ** $p < .01$.

Figure 1. Mean test performance scores across three semesters. High clicker performance = Current Semester HCP (*n* = 84), Low clicker performance = Current Semester LCP (*n* = 87).



discovery suggests that in-class clicker performance could serve as an effective diagnostic tool to identify students who are at risk for low test performance. Identifying such individuals early on as a result of being sure to include performance items along with other types of clicker items could enable targeted interventions designed to improve learning and subsequent performance.

In general, student test performance correlated positively with higher clicker activity and particularly among students who answered more clicker questions correctly. Regression analyses suggested that merely "clicking," however, does not necessarily produce desirable learning outcomes for all students and that students perform best when they mindfully and correctly answer the clicker questions posed to them. These analyses indicate that after controlling for clicker performance, just clicking may be actually negatively associated with test performance. This suggests that perhaps for some students, clickers can be distracting or otherwise unhelpful. Because clicker use and clicker performance are so highly correlated, one should interpret this last conclusion cautiously because regression weights are notoriously unstable in conditions of high multicolinearity (Cohen & Cohen, 2003). Future research, therefore, should consider more directly the extent and type of engagement that clickers engender.

Based on the current findings, I would suggest that instructors continually remind students that they should try to answer the clicker questions mindfully and to not "click just for credit." Perhaps removing the bonus credit offered for all clicker activity but continuing to offer it for correct answers to clicker questions that students can answer correctly or incorrectly would reduce this phenomenon. This, however, might also inspire equally mindless answer sharing among students – especially in the large classroom setting -- or signal to students that clicker questions without right and wrong answers (e.g., demonstrations and polling questions) are less worthy of their close attention. Furthermore, students might become frustrated with the critical thinking items. Recall that students can answer most of these items correctly or incorrectly, but that these items often appear prior to students' direct exposure to the new material into which they are leading the student. Although the intention is to encourage students to stretch their reasoning abilities, they may perceive the questions as being unfair, especially if credit is involved. For now, it would appear that a teacher should explicitly encourage students to do their best to answer questions correctly and to engage actively in lectures. In addition, teachers should be sure to allow enough time after posing a question for students to think through their answers so that they do not feel pressured to click indiscriminately. Overall, students who frequently used their clickers to give correct answers performed better on tests. Given the current empirical evidence and an abundance of literature arguing for the pedagogical advantages of using student response technology, there is a sound basis for researchers to continue to examine the interesting and promising findings reported here.
I did not experimentally manipulate clicker usage to observe its effects on test performance. Rather, I collected clicker activity data within the context of ongoing instruction. To strengthen the argument that using clickers improves test performance, however, I compared these data with that collected in courses taught in previous semesters in which students did not use clickers. Although taught in different years, the content (lectures, order of lectures, textbook, and assignments) and evaluative structure of the classes (cut-

off points for grades) across all the semesters was nearly identical. One of the comparison semesters had a slightly larger percentage of freshmen and sophomores enrolled. To the extent that all the classes were practically similar, the comparison supports the conclusion that using clickers leads to increased test performance especially for students giving generally correct answers.

Results obtained by Morling and colleagues (2008) who employed a quasi-experimental design to test the effects of clicker use on test performance further support this conclusion. Regrettably, as in the current study, the effect size they observed was minimal. In addition, these researchers only used the clickers to administer short quizzes at the beginning of class. In other words, they did not use the clickers in an interactive manner during their lecture. Stowell and Nelson (2007) evaluated the effectiveness of clickers using a more controlled experimental design that compared using clickers to other methods of soliciting student participation and drew conclusions that were largely in favor of the effectiveness of the student response system. Together these findings are encouraging, but to be more confident about the causal influence clickers have on test performance, researchers should continue to consider examining the student response system in a more controlled manner.

Future Research

Future research should include student grade point averages or similar assessments of general academic ability – such as the SAT or ACT – to help to control for the effect that academic capability might have on clicker use. Statistically controlling for academic ability would help to determine whether clicker use contributes to higher test performance or whether it simply co-varies with academic ability. I intended that students' scores on the first test of the semester would serve this purpose in the current study. Nevertheless, it was only a very rough proxy for general academic ability and entering knowledge of the subject.

Sorcinelli (2002) has suggested that teachers should use formative (i.e., ungraded) quizzes in class to increase student engagement in large classes. This technique allows students to practice multiple-choice items and analyze their responses. The student response system (i.e., clickers) can handle this activity very easily and well. It would be a mistake, however, to use the student response system as simply a means to administer quizzes. Used solely for this purpose, students might be lulled back into a "memorize and respond" mode of participation. Furthermore, merely quizzing students using the clickers without including additional instructional follow-up could lower motivation and efficacy, especially among poorer students. Under such conditions, clicking could become a deflating experience and produce conditions associated with poor academic performance. It is possible that, for some students, answering clicker questions incorrectly could lower confidence and motivation to do well in the course over time. Future research should consider whether student learning styles and goal orientations influence how different students receive and respond to the feedback provided by the student response system. Simply stated, the way teachers incorporate clickers into instruction needs further research.

Although the current study has provided evidence that students who used clickers to give generally-correct answers in class perform better on tests, future research should also explore the relative impact of different types of clicker items on course performance. For example, it would be useful to determine if factual, conceptual, and application items affect engagement and performance differently. Perhaps instructors should use an assortment of such items to engage students in a variety of ways. Well-timed factual items might encourage students to review material on a more regular basis. These items allow students to think about and respond to what they have just heard in lecture. They might also help instructors clarify themes that tie concepts together across the semester. Conceptual and application items likely do a better job of stimulating critical thinking. Items soliciting opinions from students may engage students at a more personal level than is otherwise possible in a large classroom setting. Such a form of interpersonal interaction might contribute to a sense of connectedness and engagement in learning otherwise rarely experienced in large class settings.

If instructors use the student response system thoughtfully and creatively, they might be able to tap more fully into the resources of a large class. For instance, for controversial and politically charged issues, instructors can use the student response system effectively to discretely solicit and illustrate opinions within a diverse community of learners. Students can express their opinions in the relative safety not achieved by hand raising. Incidentally, although teachers usually set software parameters to track the responses of each student, they can quickly reconfigure clicker software during a lecture to collect student responses anonymously. Furthermore, many response systems include an assortment of question formats that allow users to poll students quickly and spontaneously with preformatted true/false, multiple choice, and likert-type items. When skillfully used, teachers can seize “teachable moments” on the fly.

Conclusions and Implications

McKeachie et al. (1994) and Stanley and Porter (2002) presented good arguments that large classes are generally less effective than small ones, especially where higher-level learning goals are concerned (e.g., critical thinking, application and integration). Given the current economic environment, however, there is increasing pressure on institutions of higher education to offer large classes. It is imperative, therefore, that instructors of these classes look for ways to counter the barriers inherent in a learning environment that is likely here to stay (Benjamin, 1991). The findings of the current study suggest that a student response system can positively influence class performance, especially among those students who strive to give correct answers to in-class clicker questions. When teachers use this technology appropriately, it should counter some of the communication barriers associated with large class environments and amplify the advantage of being able to tap into the resources of many minds. Clickers may encourage some, if not all, students to engage actively with lecture material as instructors offer it. However, there is also evidence that increased clicker use among students giving generally incorrect answers to in-class clicker questions is negatively correlated with test performance. All students need to be encouraged to answer all questions posed to them mindfully and to

the best of their ability. Teachers should use a variety of questions to encourage optimal performance on all types of questions and to engage students in the lecture.

Thus, the student response system is a relatively new technology that has many promising applications. Nevertheless, as observed by ones who have both extolled and condemned PowerPoint presentations (Stoner, 2007), researchers need to carefully evaluate new teaching technology so that it is most effectively used. Technology that is effectively appropriated can open up new horizons, but technology that is poorly used can be mind-numbing and pedagogically counterproductive.

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